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THE INTERNATIONAL C2 JOURNAL

About the Journal

The International C2 Journal was created in 2006 at the urging of an international group of command and control professionals including individuals from academia, industry, government, and the military. The Command and Control Research Program (CCRP, of the U.S. Office of the Assistant Secretary of Defense for Networks and Information Integration, or OASD-NII) responded to this need by bringing together interested professionals to shape the purpose and guide the execution of such a journal. Today, the Journal is overseen by an Editorial Board comprising representatives from many nations.

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Toward Harmonizing Command and Control with Organization and Management Theory

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Abstract

A variety of academic disciplines and professional organizations address how collections of individuals and organizations combine their individual resources and efforts to accomplish collective objectives. However, these largely disjointed communities of researchers and practitioners have each developed their own concepts, models and languages. Moreover, they focus on different yet complementary issues, levels of analysis, and sets of variables. Addressing recent calls in the literature for increased semantic interoperability and interaction across these communities, we build upon current work to develop a metaphorical Rosetta Stone. The device we construct to interrelate concepts and variables across domains is in the form of a common approach space. We show how a variety of C2 Approaches and organizational archetypes can be examined—together—within a concise set of three dimensions. We also illustrate how diverse archetypes can be visualized—together—in terms of this same, three-dimensional model. This represents a substantial theoretical contribution to both the C2 and OMT domains, and it serves to bridge these domains in ways that can stimulate and facilitate mutually informed, cross-domain research.

Introduction

A variety of academic disciplines (e.g., Economics, Organization Studies, Sociology) and professional organizations (e.g., militaries, governments, corporations, voluntary organizations) address how collections of individuals and organizations combine their individual resources and efforts to accomplish collective objectives. These largely disjointed communities of researchers and practitioners have developed their own concepts, models and languages. Moreover, they focus on different yet complementary issues, levels of analysis, and sets of variables. In the language of command and control (C2) Maturity, these communities are *Conflicted*: the "whole" of their collective works remains far less than the (potential) sum of the parts (SAS-065 2008).

In the inaugural issue of the *International C2 Journal* (CCRP 2007), two papers took aim at this lack of semantic interoperability and the general failure to draw upon relevant work in related fields. This behavior is clearly not consistent with the cumulative knowledge-building tradition of science. The first of these papers (Alberts 2007) articulates a need to move beyond the very term *command and control* and the baggage of implicit assumptions and settled practice by adopting new terms and focusing on the functions associated with C2. The focus is not on how these functions have come to be approached or accomplished. The second of these papers (Nissen 2007) documents the mutual failure of the C2 research and professional communities, and a variety of related disciplines, to draw upon a more complete body of relevant works that could have resulted in a stronger intellectual foundation with an integrated set of empirical evidence to support both theory and practice. These two papers bridge initiated efforts to focus on the domains of command and control and contingency theory.

The research described here builds upon the prior work by developing multidisciplinary formulations of the C2 Approach Space and the concept *C2 Maturity*. It draws principally from, and works

to integrate, concepts and relationships from two domains of knowledge: 1) Command and Control, and 2) Organization and Management Theory (OMT). These two domains offer a very clear opportunity for productive linkage, since a great many of the activities associated with commanding and controlling pertain to organizing and managing and vice versa.

Further, we see clear theoretical advances that can be made through research along these lines. For instance, there is no single, "best" way to command and control or to organize and manage. While this axiom is well-understood in OMT, and has great applicability to C2, it is not as widely understood in the C2 community. Work along these lines can help to fill the current knowledge gap in this regard. For another instance, many organizations have the capability to change and hence to command and control or to organize and manage differently in response to varying mission-environmental conditions. Theoretical concepts and relationships from the C2 domain can inform this phenomenon in the OMT domain in novel ways and vice versa. Such mutual informing represents another theoretical advance that we hope to effect through this work.

Building upon a stream of research in both domains, the article begins by summarizing the key concepts and variables in each domain and uses the increasingly well-understood contrast between hierarchical and edge approaches to C2 and the corresponding organization and management structures to give those concepts and variables concrete application. We then develop a metaphorical Rosetta Stone, in the form of a common approach space, adapted from the C2 Approach Space (Alberts and Hayes 2006), and the concept of C2 Maturity, adapted from the NATO NEC C2 Maturity Model (SAS-065 2008), to interrelate those concepts and variables across domains. This work should contribute to a continuing process of integrating researchers, practitioners, and policy makers from these two domains and provides a foundation to support extending beyond these two domains.

Key Concepts and Relationships

In this section we summarize the key concepts and variables in the C2 and OMT domains. This provides the conceptual grist for discussion.

Command and Control

There is a substantial body of literature that addresses Command and Control. This body of literature is quite diverse and includes works that address theory, models, analyses, practice, case studies, lessons learned, and more recently C2-related experiments. While elements of this literature date back thousands of years, the portion of the literature that could be characterized as scientific has emerged much more recently. This more recent literature is a reflection of the concepts and technologies that have defined the Industrial and Information Ages. Each of these ages has left its distinctive marks on the way C2 is conceptualized and practiced. Given that the field of C2 is currently in the midst of a transformation, one that is changing the set of underlying assumptions, variables of interest, and the relationships between and among these variables, the nature of this evolution is briefly discussed before we take a look at the variables that serve to characterize C2 Approaches and organization.

Evolution in Thinking about Command and Control[1]

The term *command and control* is clearly a product of the Industrial Age. The first use of the term as we understand it appears to be by Jomini (Henri de Jomini, 1838) in *The Art of War*, when he entitles a section of the book, "The Command of Armies and the Supreme Control

1. This discussion of C2 evolution draws heavily from a peer review draft of the NATO NEC C2 Maturity Model (SAS-065 2008) and the related works of Hayes, R. E.

of Operations." It emerges as a term of art around the middle of the last century when President Truman instructs General MacArthur to "take command and control of the forces" (MacArthur 1964). Prior to this *command* was always associated with an individual (a commander) and a headquarters (a management team). Even the idea of a formal staff does not emerge before Gutaavus Adophus (1594-1632) and modern staff structures not until Napoleon Bonaparte (Alberts and Hayes 2007, Ch. 3). Since the concept of command was traditionally anthropomorphized, the term *command* became associated with the authority vested in a commander. Hence the study of command involved how particular commanders exercised this authority.

Many official definitions continue to be focused on the authorities associated with command, not on what needs to be accomplished and how it could or should be accomplished (Alberts and Hayes 1995, 5-6; Alberts and Hayes 2006, Ch. 4; NATO 2008; NATO n.d.). Since the term *command* has become "personalized," each commander is expected to have an individual style, which is a reflection (an instance) of the art of command. This approach to command fits well with the hierarchical nature of military organizations both in the Industrial Age and in prior ages, when commanders were often royal or political figures representing or being an embodiment of the state.

This "commander-centric" view of what is after all a set of functions required for mission success is totally antithetical to the way in which these functions need to be accomplished in many of the 21st century missions that militaries are being called upon to undertake. These missions are being referred to as *Complex Endeavors* to distinguish them from traditional military operations. The term *Complex Endeavors* (Alberts and Hayes 2007) refers to undertakings that have one or more of the following characteristics:

1. The number and diversity of the participants is such that

    a. There are multiple interdependent "chains of command,"

    b. The objective functions of the participants conflict with one another or their components have significantly different weights, or

    c. The participants' perceptions of the situation differ in important ways; and

2. The effects space spans multiple domains and there is

    a. A lack of understanding of networked cause and effect relationships, and

    b. An inability to predict effects that are likely to arise from alternative courses of action.

These civil-military endeavors are necessary because no single entity has the wherewithal to succeed. For a variety of reasons no single entity will be "in command." Hence, a commander-centric view makes no sense.

This reality and the opportunities provided by Information Age concepts and technologies have stimulated calls to rethink C2 (Alberts 2007). Rethinking C2 does not mean discarding everything we have learned. On the contrary, it means revisiting assumptions and building upon what remains valid. Without competent C2, military operations would never have succeeded in the past, particularly the very large operations that have been undertaken.

Modern C2 organizations trace their origins to Napoleon, who is credited with development of the first modern military headquarters and the associated creation of a "modern" command staff (Alberts and Hayes 2007). At this point in time, the functioning of

a command staff became a subject of analysis. Different militaries had different approaches to headquarters organization and correspondingly different approaches to the way in which commander's intent was expressed and control was exercised (Alberts and Hayes 1995).

It was not until the middle of the century, following Napoleon's staff innovations, that the term *command and control* began to be widely used. This raised the question of what the additional term *control* meant. Several explanations have been provided. One view maintains that command refers to what a commander does and control is associated with how the "will" of the commander becomes translated into instructions and promulgated throughout forces by the command staff (Bolger 1990). Another view parses "the art and science of command and control": command is the art, and control is the science (Schoffner 1993, 1, 31-35). The control (or scientific) aspect of C2 fit well into an Industrial Age perspective that assumed that organizations and situations could be adequately represented as machines, albeit complicated machines. Given that a machine behaves according to a knowable set of rules, results could be controlled scientifically.

This has resulted in, until very recently, a bifurcation of inquiry where the study of commanders and their behaviors continued to be a subject for military historians and the study of control became fair game for a variety of scientific disciplines. Two disciplines dominated this academic space. The first was, as seems fitting, Control Theory and the related field of Cybernetics. The second was Decision Making.

A fundamental property of Control Theory is the feedback loop. Boyd (1976-1992) is most frequently cited for his "OODA" loop[2] [3] which depicts the C2 functions of *observe*, *orient*, *decide*, and *act* as constituting a continuous feedback process. Other examples of the way the C2 problem was formulated in Control Theory can be found in the classic work by Lawson (1979; 1980), Wohl (1981), Levis and Athans (1987); and the development of HEAT (the Headquarters Effectiveness Assessment Tool; HEAT 1984) and its army counterpart—Army Command and Control Evaluation System (Hayes, Layton, Ross, and Girdler 1990).

All these specific approaches evolved from work reported to or building on a significant symposium organized by the Joint Directors of Laboratories in 1989. In essence, they decompose the military process into steps required for controlling a battlespace—monitoring the situation, developing situational awareness, developing courses of action, decision making that selects among the courses of action, developing and promulgating guidance to implement those decisions, and establishing mechanisms for feedback that allow the cycle to be continuous by monitoring the situation during implementation. They also posit that the purpose of C2 is to (a) reduce uncertainty and (b) gain control over specific parts of the situation (e.g., casualty ratios, key terrain, others). These approaches proved effective when examining Industrial Age Conflicts where situations could be decomposed into manageable arenas (e.g., intelligence, logistics, and planning) and where those situations had enough manageable parameters that they could be addressed as relatively closed, engineering type problems.

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2. John Boyd's body of work was largely documented in the form of presentations. Osinga (2007) reports that the OODA loop while described in words on a number of occasions appear only once as a graphic which he reproduces on p. 231 of his book on Boyd.

3. John Boyd's work beyond the OODA loop (which has been dismissed as being too simplistic) is relatively little known. His contributions have been documented in biographies by Hammond (2001) and Coram (2002) and are summarized in a book by Osinga (2007).

While the existence of uncertainty (e.g., the metaphorical fog of war) is an obvious given, the approaches one takes to cope with uncertainty can differ. Focusing solely on reducing uncertainty (e.g., by increasing sensors capabilities and correspondingly increasing the capability to communicate sensor reports) has its limits. There will always be a significant amount of irreducible uncertainty remaining. Van Crevald (1985) recognizes this and argues that when "confronted with a task, and having less information available than is necessary to perform the task, an organization may…design the organization, and indeed the task itself, in such a way as to enable it to operate on the basis of less information."[4]

Examples of how decision making was seen as the key to studying C2 include the work of Janis on groupthink (Janis 1982), Klein on recognition primed decision making (Klein 1998) and naturalistic decision making (Klein and Salas 2001), and Weick on sensemaking (Weick and Sutcliffe 2001). Sensemaking (making sense of the situation) is a set of cognitive processes that begins when awareness reaches a certain level and ends with a formulation of intent (a decision to act).[5] Thus, sensemaking is a bridge between developing awareness and acting. Military-related human factors research, Endsley (1988, 1989, 1990) and Bolstad and Endsley (1999) for example, have traditionally been focused on understanding and improving individual and small team situation awareness in a tactical context. However, the definition of situation awareness includes what others refer to as knowledge and understanding. Furthermore, this body of work

4. This quote is part of a larger discussion and the organizational-task design suggestion is an alternative to increasing information-processing capability. See Van Crevald (1985, 251-60).

5. A comprehensive discussion of the variables related to the analysis of Information Age warfare in the physical, information, and cognitive domains (the cognitive domain in this treatment included variables that later became referred to as the social domain) including awareness, and understanding and shared awareness and shared understanding as part of an evolving sensemaking process can be found in Alberts et al. Understanding Information Age Warfare (2001).

seems to imply that there is in fact a single version of ground truth and hence makes its extension to a coalition environment problematic. This focus on decision making can also be found in the works of theorists who see command as the key issue such as Allard (1995) and Pigeau and McCann (2002).

These approaches emphasize the nature of the decisions being made and the individuals making them. They place the burden on understanding how people make decisions (e.g., from cognitive psychology to theories of learning and knowledge) and the limits of individual cognition. Unfortunately, this school of thought focuses analyses of C2 inward on the processes and people involved. Like control theory, these approaches should not be ignored. They represent a part of the understanding needed to analyze C2. However, Complex Endeavors require a larger perspective and a broader understanding of what is needed for C2 to be successful.

During the latter part of the 20th century, technology became an increasingly important consideration. Communications technology became so important that the term *C2* became *C3* for Command, Control, and Communications. The Information Age dawned, and with it the term evolved further to *C3I* (the "I" for Intelligence) and again to *C4I* (the fourth "C" being Computers). The study of C2 evolved along with the language. There was an increasing emphasis put on communications-related metrics such as the probability of correct message receipt (Perry, Signori, and Boon 2003) and measures of information throughput (HEAT 1984). The focus of research during this period moved from a preoccupation with a commander to a preoccupation with C2 (C3, C3I, C4I) systems. Unfortunately, the C2 systems and engineering communities remain preoccupied with C2 systems. Fortunately there are significant activities emerging in other communities. For example, there is important attention now being focused on team, group, and collective behaviors related to accomplishing the functions associated with C2.

Despite this emerging focus on collective behaviors, the bulk of research and analysis of C2 systems has and continues to be "commander-centric" and focuses on the related decision making processes. In the Industrial Age, command was all about the commander. In the Information Age the emphasis shifted to technical systems. However, these systems continued to be conceived, designed, and operated as essentially vertical pipes of information that centered primarily on a *commander* or the command staff.[6] The only decisions considered worthy of attention are those made by a commander or the command staff. This view keeps the tradition of the "art of command" and a "commander-centric" view in place, driving how communications and information systems and C2 processes are conceived and studied.

21st century mission challenges in the form of Complex Endeavors and the continued maturation of networking (e.g., social, communications, information) concepts, technologies, and services combined have to create a schism between the ways in which C2 was and, for the most part, still is conceptualized, studied, and practiced and what is required for success. This disconnect is not limited to the military. Networking capabilities have not only fundamentally changed the economics of information (Alberts, Garstka, and Stein 1999), but they have also changed the way individuals and organizations relate to one another throughout society.

The idea that military institutions in general and C2 in particular should co-evolve with advances in information technologies (Alberts, Garstka, Hayes, and Signori 2001) was central to a new theory of warfare, *Network Centric Warfare* (NCW), as it was coined in the United States (Alberts et al. 1999; DoD 2001b). NCW suggested a new relationship between those in positions of command and those responsible for the large variety of functions that need to be accomplished in military operations. As a consequence, ideas that foreshadowed

6. Once a commander made a decision, information in the form of orders or plans would be communicated to subordinates.

the conceptualization of NCW, such as information being "freed from the chain of command" (Alberts 1996, 15-20, 33-40; Alberts and Hayes 2003), and questions that challenged the existence of a single chain of command (Mauer 1994; Allard 1995; M. Hayes and Wheatley 1996; Alberts and Hayes 1995), set the stage for the linchpin of NCW, *self-synchronization* (Alberts et al. 1999; Alberts et al. 2001).

A further step in the process of making the study of C2 less personalized was the change in the term *commander's intent* to *command intent* (Alberts and Hayes 2006). This change highlighted both the fact that there are many decision makers (cf., commanders only) in any battlespace or Complex Endeavor and the fact that no single person is in charge or in command during Complex Endeavors (R. E. Hayes 2007).

While NCW suggested a new way of looking at how to accomplish the functions associated with C2, many chose to ignore this "suggestion" and chose to focus instead on providing the information infrastructure to support network centric operations, thereby ignoring the need to explore new approaches to C2. The term *NEC*, Network Enabled Capability, adopted by NATO and several countries, effectively encourages an emphasis on the development of "kit" rather than the exploration of new approaches to accomplishing the functions associated with C2.

The lack of attention to the co-evolution of cognitive and social processes is the aftermath of the introduction of NCW and demanded a response. The articulation of a set of *Power to the Edge* principles and related policies (DoD 2003) was such a response. *Power to the Edge* directly addresses the seismic shift in relationships required to leverage shared awareness to foster self-synchronization and achieve dramatic improvements in mission effectiveness. *Power to the Edge* thus explains what NCW left to the imagination, that is, the "magic" that connects the links in the network-centric value chain (Alberts and Hayes 2003).

From both a theoretical and an analytical point of view, the emergence of NCW and *Power to the Edge* served to focus attention on a new set of independent variables, including but not limited to those variables that specify a particular approach to C2 (Alberts and Hayes 2006; Alberts and Hayes 2007). The idea of a C2 Approach Space that includes non-traditional approaches to military organization is quite revolutionary. It clearly moves C2 organization and doctrine from an assumption to a treatment in the experimentation sense. Without this shift in the conceptual framework, there would be no feasible solution to the problem of civil-military coalition C2 or what is called "collective C2" (SAS-065 2008).

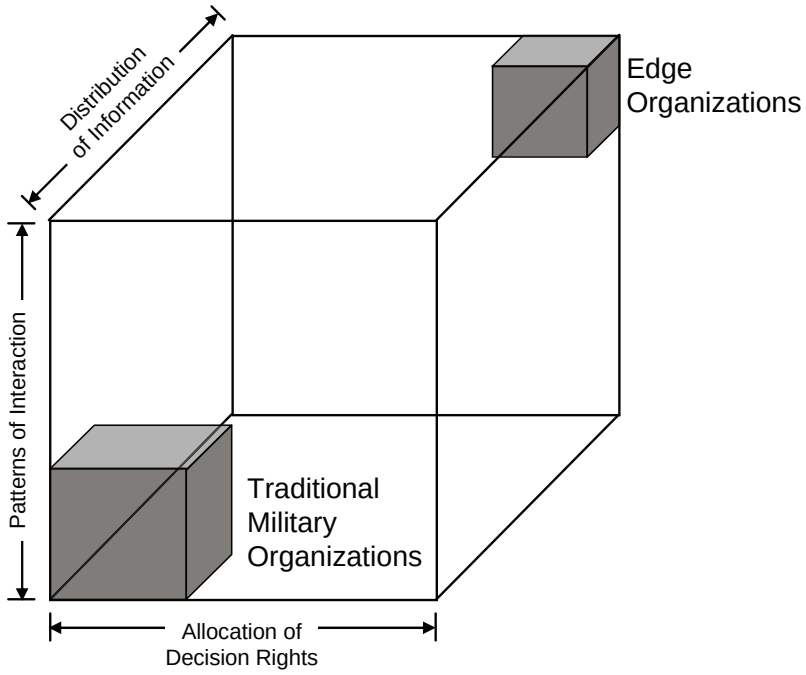

Figure 1. C2 Approach Space (adapted from Alberts and Hayes 2006)

The three dimensional approach space depicted in Figure 1 can be used to describe a wide variety of approaches to accomplishing the functions associated with C2 for a diverse set of teams, organizations, or collectives of entities. The three dimensions that form the C2 Approach Space, while graphically depicted as orthogonal, are, in fact, interrelated. The allocation of decision rights (ADR) considered from either the perceptive of a single organization or a collection of entities establishes a set of constraints and influences that impacts the other two dimensions. The end points of ADR are "none" and "broad," indicating no delegations of authority and that authorities are widely distributed. The closer to "none" that an organization falls on this scale, the greater the likelihood that the patterns of interaction (PoI) and distribution of information (DoI) will be constrained.

The area around the origin corresponds to traditional military C2 and organization, while the opposite corner of this space corresponds to what has become known as "edge organizations" (Alberts and Hayes 2003). The language used to refer to each of the three dimensions as well as their respective end points needs to be tailored to the application. For example, in the case of an organization with well-established and very limited delegations of authorities, the ADR (within the organization) can be thought of in terms of a centralized-decentralized continuum. In the case of a collective of disparate entities (e.g., as in the "self" of a Complex Endeavor), the ADR dimension has been labeled as the "allocation of decision rights to the collective," where "none" indicates that each individual entity maintains whatever decision rights it has, and "broad" indicates that entities are willing to give up significant sovereignty.

The PoI dimension spans a continuum from "highly constrained" to "unconstrained," while the DoI dimension spans a spectrum from "none" to "broad." In practice, individuals in organizations that control information tightly will only have access to what is thought to be of interest to them a priori. Thus, available information will not be widely dispersed. Individuals in organizations that facilitate

and encourage widespread sharing of information will, on the other hand, have access to more of the available information. If and how well they utilize this additional access to information depends on a great many other factors.

Another development has contributed to the reconceptualization of C2. This development strikes at the assumption that one can optimize C2 or C2 Approach. One cannot and should not think about "optimizing" C2 in the 21st century. There is no single approach, no best system design or configuration, no best process for all situations and circumstances. Military planners cannot adequately predict the exact nature of 21st century missions. However, there is one certainty. Those missions are more likely to involve Complex Endeavors characterized by complexity in the environment and the effects space, and the complexity inherent in the collective (nature of the set of entities needed to respond) (Alberts and Hayes 2006).

Thus, rather than trying to optimize, one needs to focus on *agility*, where agility is the capability to maintain effectiveness in the face of changing circumstances and a variety of stresses (Alberts 2007).[7] To engineers and analysts this development creates both a fundamental challenge and an opportunity. The challenge is to rethink an approach and process that assumes a level of understanding that simply is not present in most relevant efforts. The fundamental changes in the way we need to think about C2 call into question the very language we have used to talk about C2 and, in fact, the term itself.

7. Agility is discussed in more detail in the section on Key Command and Control Variables.

C2 in Context of a Complex Endeavor (Collective)[8]

C2, until quite recently, has been associated with a single organization or with coalitions that try to act as if they were a single organization. Complex Endeavors involve collections of entities that clearly do not want to be or act like a single entity. Hence, there is a need to also address the collective itself, rather than just the individual entities that make up the collective. However, a collective is fractal in nature. That is, there is an entity structure[9] that needs to be described and understood at each of a number of different scales. This is illustrated in Figure 2 where the basic structure consists of entities linked to each other through their interactions. Both the basic structures and the nature of interactions can be qualitatively different across entities as a function of scale. As an example of the differences at the various entity levels, we might consider teams (e.g., military units), organizations (e.g., military and civilian), and collectives (e.g., the overall coalition and wider contributors):

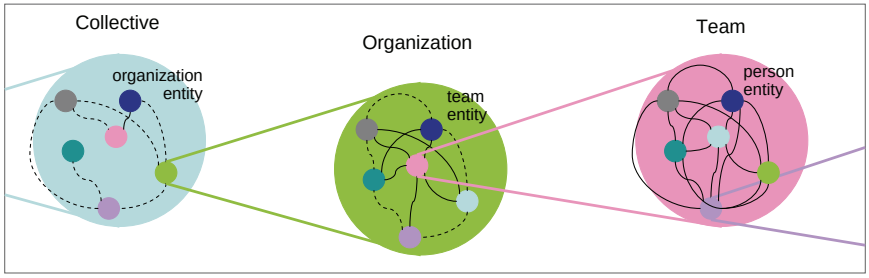

Figure 2. Fractal Nature of Entities with Qualitatively Different Interactions[10]

8. This section draws heavily from the peer review draft of the NATO NEC C2 Maturity Model (SAS-065 2008; the lead authors were Moffat, J. and Alberts, D.).

9. It is the idea of entities comprised of other entities that makes this fractal in nature, even if these constituent entities may be, in fact, very different in structure. This is because we are looking at inter-entity relationships and behaviors.

10. Adapted from SAS-065 2008; this figure was conceived by James Moffat.

Team – Multiple people work together with high levels of common intent towards a common objective. They train together and develop a common work culture. The team typically consists of a leader and followers who fully understand each other's competencies, authorities, and responsibilities.

Organization – Multiple teams bound by a common vision, a common mission, core values, monetary incentives (typically), business rules, legislation, policy, well-established communication and interaction, and some degree of common shared intent required to achieve the mission and realize the vision.

Collective – Multiple loosely-coupled organizations that might work together if in their best interest, or sometimes for the greater good or a collective purpose. Note that the links may be less robust with less of a central tendency than in teams or organizations. The organizations that make up the collective each bring specific and complementary capabilities. They may also have different intents as well as exhibit different C2 Maturity levels. A collective matures more by adaptation (given enough time working together) and less by deliberate design (legislation, policy, and training).

Key Command and Control Variables

As the thinking about C2 has evolved over time, so have the variables that have captured the attention of C2 researchers and analysts. The interest in the quantitative assessment of C2 became increasingly fashionable in the 1970s. By 1979 the Office of the Secretary of Defense organized, at the National Defense University, a conference and workshop to review the state of the art and signal an interest in improved C2 analysis (DoD 1980). The sponsors, the Director, Net Assessment, and the Assistant Secretary of Defense (C3I), both desired to better understand and improve C2 organizations, capabilities, equipment, and reduce vulnerabilities. They were therefore

interested in measuring the utility of communications, intelligence, warning, surveillance, reconnaissance, and other support functions for the purposes of C2 force trade-offs and planning and budging priorities.

The independent variables used at this time and for years to come were related to 1) systems performance, 2) measures of information quality, and 3) measures related to decision quality. The contributions of C2 to mission effectiveness were considered to be bound by assumptions of perfect communications and perfect and timely information. Virtually all of the effort in analyses and in C2 investments were made to improve the systems that supported C2, not C2 itself.

This continued well into the 1990s, when a more sophisticated value chain was introduced along with the concept of network centric warfare. This value chain was presented in the form of a set of tenets depicted in Figure 3 (based on DoD 2001a).

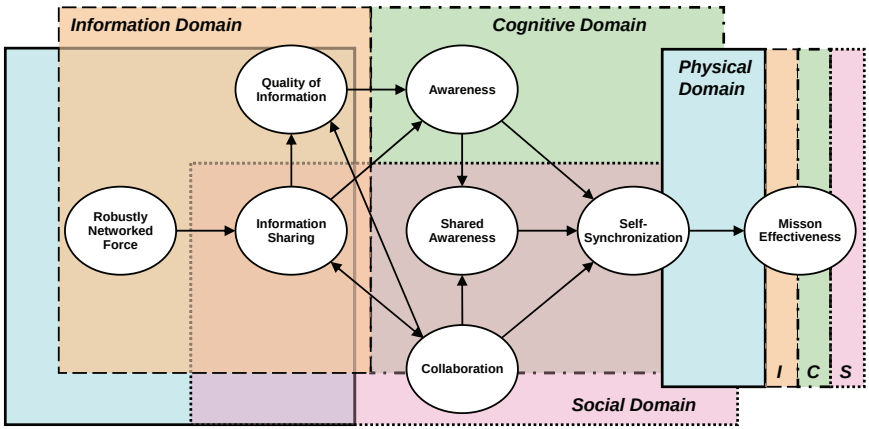

Figure 3. Network Centric Value Chain

The Network Centric Value Chain begins with a robustly networked force, which increases information sharing. Information sharing improves both the quality of information and shared awareness. Shared awareness enables self-synchronization and improves mission effectiveness. This focuses attention on a set of intermediate key variables that explain why moving to a more connected force (e.g., why investments in communications and information processing capabilities) leads to improved mission effectiveness. At the same time a new mental model of C2 was introduced that provided additional context and granularity. This mental model placed the Network Centric Value Chain in the context of the physical, information, cognitive, and social domains (see Figure 3) (Alberts et al. 2001, 71-76).

While NCW created a stir when it was introduced, it did not fundamentally change the basic assumption associated with military C2, that of a chain of command. However, it did argue for rethinking the allocation of decision rights and the way commander's intent could be expressed.

The next fundamental change occurred, not to the set of independent variables but to the set of dependent variables. At this point success was synonymous with improvements in mission effectiveness, as defined by a set of planning scenarios. Given the uncertainty associated with the next security or mission challenge, both as to the nature of the situation that could arise and the nature of the coalition needed to meet this challenge, the specification of a set of scenarios to frame an optimization problem became itself problematic. The nature of scenario-based analysis problems are compounded when one is required to consider all of the things that could go wrong or not according to plan. Mission effectiveness turns out to be nice in theory but impractical to use in practice given the uncertainties associated with the mission space and mission performance.

A better approach has been suggested. Rather than focus on mission effectiveness, which requires a specific scenario, it has been suggested that one focus instead on agility. Agility is the ability to successfully cope with a variety of circumstances and stresses.[11] Threats to successfully coping can come from a variety of sources. The six components of agility are: 1) robustness, 2) flexibility, 3) responsiveness, 4) resilience, 5) adaptability, and 6) innovation (Alberts and Hayes 2003). Thus, this set of variables has been added to the growing list of variables of concerns important to C2 researchers and analysts.

C2 Approaches

Five archetypical C2 Approaches have been defined and mapped to different regions of the C2 Approach Space. These five include: 1) Conflicted C2, 2) De-Conflicted C2, 3) Coordinated C2, 4) Collaborative C2, and 5) Edge C2. Figure 4 depicts how these archetypical C2 Approaches are mapped to the axes of the approach space. Note that the boundaries between C2 Approaches depicted in this figure (e.g., the place where De-Conflicted becomes coordinated) are fuzzy and not delineated sharply. We use this graphic device to convey approximate relations between the C2 Approaches and dimensional axes, so as not to imply precise definition or measurement.

11. The CCRP sponsors a monthly meeting of interested researchers and analysts that is devoted to discussions of issues related to agility, focus, and convergence. This group reached this consensus one-line definition of agility.

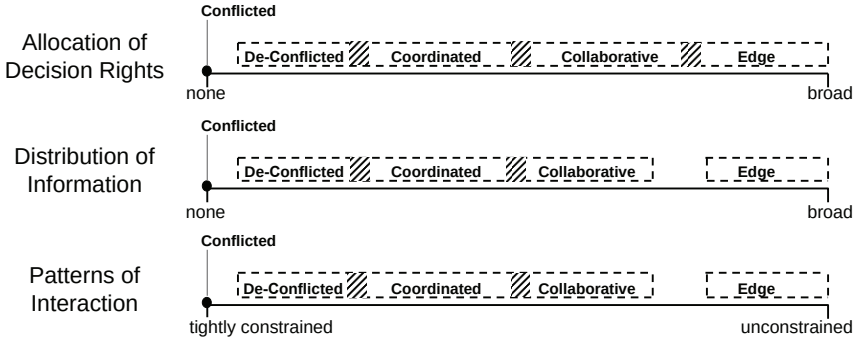

Figure 4. C2 Approach Space Dimensions (adapted from SAS-065 2008)

Figure 5 creates a three dimensional view of the C2 Approach Space and plots the five C2 Approaches according to the three axes depicted above.[12] Point A corresponds to Conflicted C2 and occupies an extreme point on the lower left frontal corner of the space (i.e., no allocation of decision rights, no distribution of information, and no interaction). Notice the progression of C2 Approaches depicted in the figure across a rough diagonal from Point A to Point H; that is, as the C2 Approach progresses from Conflicted through De-Conflicted, Coordinated and Collaborative to Edge C2, their

12. It should be noted that the NATO study was done specifically in the context of Collective C2, that is, the arrangements and behaviors that are associated with C2 from and the perspective of the collective. It was assumed that different entities would each have their own C2-related capabilities and internal approaches to C2, or in the case of non-military organizations, their own organizational structures and approaches to management. What the NATO group focused on was how these independent (and interdependent) entities worked collectively. Thus, the definitions of the three axes of the Approach Space were cast in this context. For example, with respect to the allocation of decision rights (none to broad), what was considered was the extent to which these rights were allocated or delegated to the Collective; for the patterns of interaction (none to broad), the patterns of interest were between and among the entities; and, for the distribution of information (none to broad), the perspective was how information was distributed across entities.

corresponding positions in the C2 Approach Space shift from the lower-bottom-left to the upper-top-right corners of the space (i.e., broad allocation of decision rights, broad distribution of information, and unconstrained patterns of interaction).

The reader will note that Figure 5 depicts no overlaps between the approaches (i.e., each approach occupies a distinct region of the space). The fuzziness between the boundaries in Figure 4 is not meant to imply overlaps but rather that the exact positioning of the break points between one approach and another on these axes is not definitively known at this point in time.[13]

13. Notice also most C2 Approaches are depicted in the figure as rectanguloid volumes instead of points. This represents the approximate relations between the C2 Approaches and dimensional axes noted above. Finally, notice that most vertices (e.g., labeled "B," "C," "D," and so forth) do not have C2 Approaches associated with them. Indeed, the five C2 Approaches represented in this figure occupy a relatively small volume of the approach space. This suggests that the number and positioning of feasible C2 Approaches may be relatively small, but exploring the nature, feasibility, and comparative performance of alternate approaches (e.g., represented by moving from the diagonal toward Points B,C,F, and G) represents an intriguing avenue for future research.

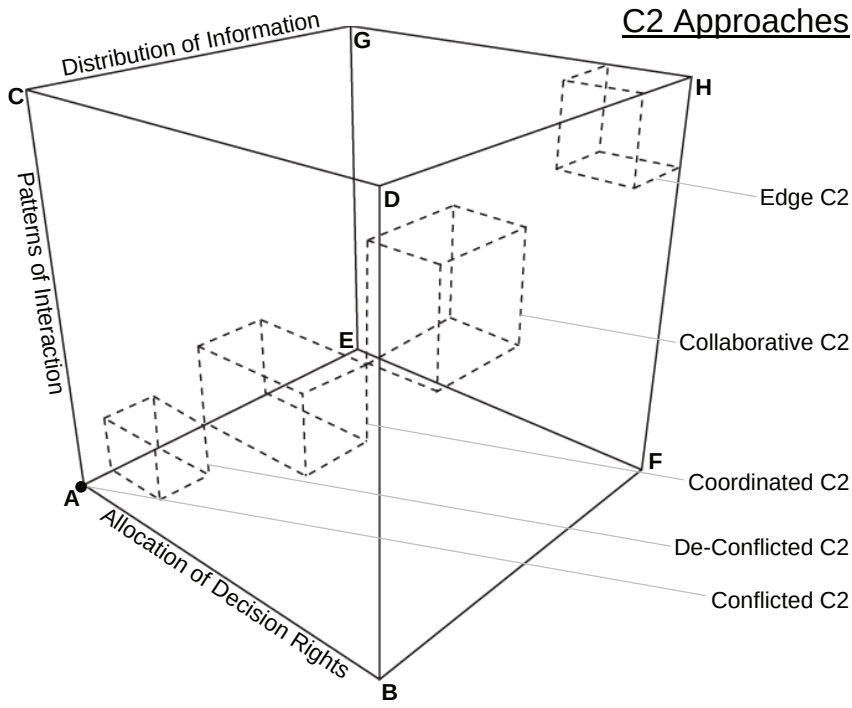

Figure 5. C2 Approach Space

The ability of an organization or a collective to progress in its C2 ability from the lower-bottom-left of the C2 Approach Space (i.e., Conflicted C2) to the upper-top-right (i.e., Edge C2) is related to the concept *C2 Maturity*, a concept which emerged recently in the C2 research literature (SAS-065 2008). As an organization becomes capable of operating farther and farther along this diagonal, it develops the ability to operate across a larger volume of the C2 Space. For instance, an organization capable of Coordinated C2 could also implement either De-Conflicted or Conflicted if it chooses to; likewise, an organization capable of Collaborative C2 could also implement Coordinated, De-Conflicted or Conflicted, and an organization capable of Edge C2 could implement any approach. The interested reader is referred to (SAS-065 2008) for details.

Thus, the five archetypical C2 Approaches serve as the basic building blocks of C2 Maturity. However, simply being able to adopt a greater variety of C2 Approaches is not sufficient; C2 Maturity also implies knowing which approach is appropriate to the situation and an ability to transition from one C2 Approach to another in a timely fashion. Therefore, different levels of C2 Maturity can be described in terms of the range of C2 Approaches that an organization can appropriately adopt.

Organization and Management Theory

The name *Organization and Management Theory* serves to represent an enormous body of theoretical and empirical research that has taken place over the past century. At its core, OMT involves the activities organizing and managing, which we characterize here as follows. Drawing from both rational and natural definitions (Scott 2003), organizing involves establishing the manner in which participants in a collective (e.g., people, groups, organizations) work toward the accomplishment of (at least partially) shared objectives. Managing involves coordinating the activities (e.g., decision making, information sharing, working) of such participants.

Here we summarize the key OMT concepts from Contingency Theory, which provides a highly relevant basis for comparison with the concepts from the C2 literature identified above. We then draw from important OMT work on organizational archetypes to identify a useful set of organizing and managing variables for comparison with C2 variables. We complete this section by using such OMT concepts and variables to specify several organizational archetypes for comparison with the field of C2.

It is important to understand that this literature goes well beyond theoretical description. Despite the word "theory" in its title, the Contingency Theory literature includes an enormous amount of empirical research that demonstrates the practical application of

such theory to improve the performance of operational organizations in the field. Although describing specific examples is beyond the scope of this paper, the interested reader is directed to the references cited below to such empirical literature.

Contingency Theory

Within the enormous body of OMT literature, the Contingency Theory (CT) subfield emerges as the most relevant for comparison and integration with C2 (Nissen 2007): CT involves purposeful design and change of organizations to fit their environments and other contingencies (e.g., strategies, technologies, people). Such purposeful design and change reflects a fundamentally rational, teleological view of organizing and managing, a view which is ascribed widely to those involved with C2.

Further, for more than a half century, Contingency Theory has retained a central place in organization and management research. Beginning with seminal works by Burns and Stalker (1961), Woodward (1965), and Lawrence and Lorsch (1967), Organization and Management Theory has been guided by the understanding that no single approach to organizing is best in all circumstances.

Moreover, myriad empirical studies (e.g., Argote 1982; Donaldson 1987; Hamilton and Shergill 1992; Keller 1994; cf., Mohr 1971; Pennings 1975) have confirmed and reconfirmed that poor organizational fit degrades performance. Moreover, many diverse organizational structures (e.g., Functional, Decentralized, Mixed, see Duncan 1979), forms (e.g., Bureaucracy, see Weber and Parsons 1947; M-Form, see Chandler 1962; Network, see Miles and Snow 1978; Clan, see Ouchi 1980; 1981; Virtual, see Davidow and Malone 1992; Platform, see Ciborra 1996), configurations (e.g., Machine Bureaucracy, Simple Structure, Professional Bureaucracy,

Divisionalized Form, Adhocracy, see Mintzberg 1979), and other groupings[14] have been theorized to enhance fit across an array of contingency factors (e.g., age, environment, size, strategy, technology).

Indeed, organization and management scholars have come to understand well how various organizational forms are and should be designed and changed to fit specific contingency contexts. For instance, organizational technology has been studied extensively as a powerful contingency factor (e.g., Litwak 1961; Woodward 1965; Pugh, Hickson, Hinings, and Turner 1969), with alternate technological characteristics (e.g., task variability, problem analyzability) related contingently to different organizational forms (e.g., Craft, Engineering, see Perrow 1970). As another instance, organizational environment has also been studied extensively as a powerful contingency factor (e.g., Burns and Stalker 1961; Harvey 1968; Galbraith 1973; 1977), with alternate environmental characteristics (e.g., complexity, change) related contingently to different organizational structures (e.g., Functional, Decentralized, see Duncan 1979).

Organizational Archetypes

We draw from Mintzberg's work on organizational archetypes (Mintzberg 1979) and build upon detailed specifications[15] to characterize such archetypes in terms of OMT concepts and variables

14. As a note, although we recognize differences in meaning between terms such as *organizational structure, form, configuration* and others (e.g., see Doty et al. 1993; Meyer et al. 1993; Morrison and Roth 1993; Snow et al. 2005; Payne 2006), unless the specific meaning is important to our argument. In this article we use them interchangeably for the most part.

15. This follows prior work (Orr and Nissen 2006) to specify organizational archetypes with sufficient precision for representation via computational models. Such specification requires making several assumptions regarding Mintzberg's variables, but makes the meaning of each variable comparatively precise, particularly with respect to natural-language description comprising the majority of the OMT (and C2) literature(s).

that can be mapped to many of those from the C2 domain identified above. Examining archetypes is very useful, for each represents a *class* of organization and, hence, describes a broad array of organizational instances. Indeed, Mintzberg proposes that almost all organizations can be described by only five organizational archetypes: 1) Simple Structure, 2) Machine Bureaucracy, 3) Professional Bureaucracy, 4) Divisionalized Form, and 5) Adhocracy. Each approach to organizing can be characterized in terms of five elements: 1) operating core, 2) strategic apex, 3) middle line, 4) technostructure, and 5) support staff. Each approach to managing can be characterized in terms of five coordination mechanisms: 1) mutual adjustment, 2) direct supervision and standardization of 3) work processes, 4) outputs, and 5) skills.

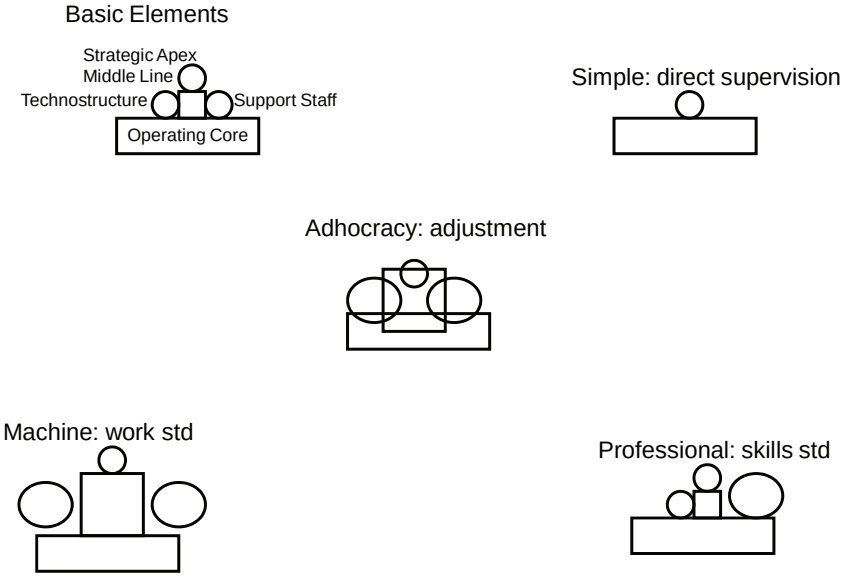

Figure 6. Organizational Elements and Coordination Mechanisms

Drawing heavily from (Nissen 2005), Figure 6 summarizes these organizational elements. The basic elements are shown in the upper- left quadrant. The *strategic apex* is shown as a circle at the top

of the organization. This is where strategic organization, management, and leadership are accomplished in most views of organizing and managing. The *middle line* is shown as a square below the apex. This is where line organization, management, and leadership take place. The *operating core* is shown immediately below the middle. This is where the basic product and service outputs of the organization are accomplished. On either side of the middle line are the *techno-structure* and *support staff*. Like the middle line, these two elements sit between the strategic apex and the operating core, but as staff organizations they are not part of the direct line between the apex and core. The technostructure is responsible for direct support such as planning, analysis, and technology. The support staff is responsible for indirect functions such as accounting, legal counsel, and building maintenance.

Different organizational archetypes can be depicted and differentiated graphically using these elements. For instance, the Simple Structure (labeled "Simple: direct supervision") is depicted in the upper-right quadrant. It includes only two of the five elements: 1) strategic apex and 2) operating core. The strategic apex is emphasized by making it prominent. In this archetype, coordination is attained principally through direct supervision. Most very small businesses are organized in this way.

In contrast, the Machine Bureaucracy (labeled "Machine: work std") is depicted in the lower-left quadrant. It includes all five elements, with three elements emphasized by making them prominent. Specifically, the middle line is depicted using a relatively large square, and both the technostructure and support staff are depicted similarly using relatively large circles. This depiction represents the relatively large numbers of layers of middle management and relatively large size and influence of technical and support staffs. In this archetype, coordination is attained largely through standardization of work processes. Most large firms, military commands, and gov-

ernment agencies organize along these lines. Indeed, the C2 term *hierarchy* corresponds very closely with this Machine Bureaucracy archetype (Nissen 2005).

A third instance includes the Professional Bureaucracy (labeled "Professional: skills std"), which is depicted in the lower-right quadrant. It includes all five elements also, but both the operating core and support staff are emphasized by making them prominent. Here standardization of skills provides the principal means of coordination among professionals in the operating core. Most professional corporations (e.g., legal firms, medical offices, consultancies) organize this way.

A fourth instance includes the Adhocracy (labeled "Adhocracy: adjustment"), which is depicted in the center. It includes all five elements also, but they are blended together to depict much less structure and differentiation than is present in the other archetypes. Here mutual adjustment provides the principal means of coordination. Many new firms, agencies, and organizations (e.g., startup firms, innovation-oriented companies, non-profit groups) are organized as loosely structured Adhocracies.

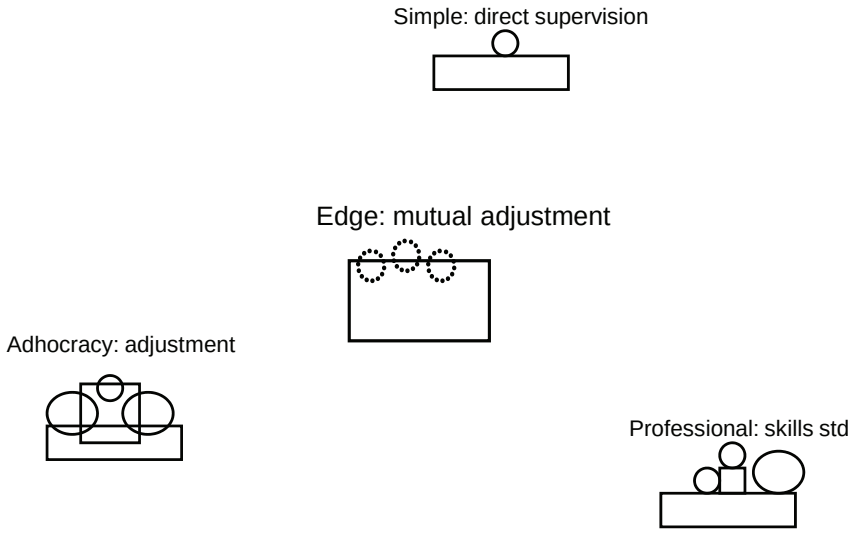

Figure 7. Edge Organization

It is important to understand that these organizational elements and coordination mechanisms can be put together in many different ways and that they can change dynamically. For instance, the Edge organization (Alberts and Hayes 2003) integrates aspects of multiple archetypes. Like the Simple Structure, it reflects low specialization; like the Professional Bureaucracy, it reflects a prominent operating core; and like the Adhocracy, it involves coordination via mutual adjustment. However, it lacks the other organizational elements. Indeed, the Edge can be viewed as a hybrid archetype, yet it appears to be distinct (Gateau, Leweling, Looney, and Nissen 2007; Orr and Nissen 2006) in that *only* an operating core is involved. Leadership is emergent in the Edge meritocracy environment, which we depict by different dotted circles (e.g., corresponding to different leaders emerging at various times) extending only partially from the operating core in Figure 7, which we include along with the three archetypes from which it draws greatly.

We should note at this point that Mintzberg published a considerable volume of scholarly work beyond the discussion of archetypes summarized above (e.g., managerial work, Mintzberg 1973, organizational power, Mintzberg 1983, strategy, Mintzberg 1991, and others). Indeed, even in the work cited above (479-480) he proposes a sixth archetype called the Missionary Configuration, which would use standardization of norms as the primary manner of coordination and would stress indoctrination as the principal design factor.

In addition to using the organizational elements and coordination mechanisms for classification and depiction, Mintzberg introduces eight variables associated with organizing and managing, what he terms *design factors*, to specify and contrast the archetypes. Such variables enable us to be more precise in terms of specifying the different archetypes and provide a basis for interrelating them with key concepts and variables from the C2 field.

Table 1 summarizes the archetype variables. *Centralization* pertains to the breadth of decision rights. *Specialization* refers to the division of labor and includes two dimensions: 1) vertical refers to the limitedness of job control, and 2) horizontal refers to the narrowness of job breadth. The greater the vertical or horizontal specialization, the less the job control or breadth, respectively. *Formalization* represents the extent to which work processes are specified formally (e.g., via rules, policy manuals, written procedures, job instructions). *Liaison devices* involve means of horizontal interaction (e.g., between functions) and can include approaches such as informal exchanges, task teams and matrix organizations. *Planning and control* refers to how outputs are managed. This includes action planning or performance control. Although planning and control represent complementary variables, we discuss these two together to mirror Mintzberg's original presentation.

Table 1. Archetype Variables

Design Factor	Meaning
Centralization	Breadth of decision rights
Vertical specialization	Limitedness of job control
Horizontal specialization	Narrowness of job breadth
Formalization	Formalization of work processes
Liaison devices	Means of horizontal interaction
Planning & control	Management of outputs
Training	Formal education & training
Indoctrination	Intensity of acculturation & norming
Unit grouping	Composition of organizational units
Unit size	Span of control

Training and indoctrination can be split into two subfactors. Training involves the degree of formal education and training organizational participants receive (usually in advance of beginning a job). Indoctrination involves the intensity of acculturation and norming forces associated with an organization. *Unit grouping* refers to how organizational units are composed. This can be by function (e.g., skill, knowledge, business process) or market (e.g., product, geography, demographic). Finally, *unit size* refers to managerial span of control. With these design factors, we have the ability to characterize a broad diversity of organizational instances through archetypes as well as a set of variables to both specify and contrast diverse instances.

Specifying Organizational Archetypes

Using the concepts and OMT variables from Table 1, we can specify each of the five organizational archetypes (i.e., Machine Bureaucracy, Simple Structure, Professional Bureaucracy, Adhocracy, Edge).

Table 2. Archetype Specifications

OMT Variable	Machine Bureaucracy	Simple Structure	Prof. Bureaucracy	Adhocracy	Edge
Centralization	High	High	Low	Low	Low
Vertical Specialization	High	High	Low	Low	Low
Horizontal Specialization	High	Low	High	High	Low
Formalization	High	Low	Low	Low	Low
Liaison Devices	Few	Few	Some	Many	Many
Planning & Control Systems	Action Planning	Little	Little	Some Action	Performance Control

Table 2 contains the OMT variable values for each of the archetypes, thus constituting a specification. For instance, Column 2 summarizes specifications of the Machine Bureaucracy and reflects its high centralization, specialization, and formalization levels. The other variables and levels follow accordingly for the Machine Bureaucracy and other archetypes. In addition to relatively extreme labels (esp. "high" and "low"), we include some intermediate values (e.g., "some" and "little") to suggest that certain archetypes and variables are not characterized by such extreme values.

Conceptual Integration

In this section we identify how the C2 and OMT concepts and variables map to each other. This provides the basis for the development of a metaphorical Rosetta Stone for interpretation and comparison across these two fields. Table 3 includes a set of variables across the C2 and OMT literatures that appear to match in part. These C2

variables derived from the C2 Approach Space include: *allocation of decision rights*, *patterns of interaction*, and *distribution of information* (Alberts and Hayes 2006). The OMT variables were derived from Mintzberg (1979). Notice that not all of the OMT variables from Table 1 have been included. This suggests that our effort to harmonize C2 and OMT remains only partially accomplished at this point. We address the correspondences between and among these variables and then present some additional C2 variables briefly for reference.

Table 3. Partially Matching Variables across Domains

C2 Variable	OMT Variable
Allocation of Decision Rights	Centralization Vertical Specialization Horizontal Specialization
Patterns of Interaction	Formalization Liaison Devices Planning & Control Systems
Distribution of Information	Liaison Devices Planning & Control Systems

Allocation of Decision Rights (ADR)

The OMT variable *centralization* appears to be a good match with *allocation of decision rights* (ADR). In terms of the ADR continuum ranging from none to broad, the former corresponds closely to a highly centralized authority, while the latter corresponds to a decentralized organization. The OMT variables related to specialization also seem to map to ADR. When there is a lack of specialization, that is, if individuals and/or entities can decide for themselves what to focus on and what tasks to undertake, this maps to an ADR value of "broad."

On the other hand, to the extent that formal specialization occurs (moving along the axis toward "none"), then it would be expected that those decision rights associated with each area of specialization would only be associated with specialists. *Vertical specialization*, to the extent it exists, limits job control; that is, the greater the vertical specialization, the less control individual actors have over their job duties and vice versa. *Horizontal specialization* pertains to narrow job breadth; that is, the greater the horizontal specialization, the lesser breadth associated with individual's jobs and vice versa. Narrow and broad degrees of specialization correspond, respectively, with constrained and unconstrained patterns of interaction. That is, people who lack much breadth in their job duties tend to have restricted patterns of interaction and vice versa.

The classic hierarchy, Machine Bureaucracy archetype exhibits high centralization, vertical and horizontal specialization. Alternatively, the novel, flat, Edge archetype (by definition a decentralized entity) has, in the ongoing series of experiments using the ELICIT environment, consistently exhibited relative lack of vertical and horizontal specialization when compared to the behaviors recorded for The Hierarchy experimental treatment.

The remaining discussion of the correspondences between and among C2 Approach Space dimensions and selected OMT variables are empirically informed by the results of a series of international experiments.[16]

Patterns of Interaction (PoI)

The extent of specialization (a property associated with ADR) directly affects the PoI. Narrow and broad degrees of specialization correspond, respectively, with constrained and unconstrained

16. See http://www.dodccrp.org/html4/elicit.html for links to some of the papers that discuss these experiments.

patterns of interaction. That is, people who are unconstrained with respect to their job duties tend to have less restricted patterns of interaction and vice versa.

Three OMT variables seem to map reasonably well to PoI, characterized along a continuum ranging from tightly constrained to unconstrained. *Formalization* characterizes the extent to which work processes are specified formally (e.g., via rules, policy manuals, written procedures, job instructions). High and low degrees of formalization correspond, respectively, with constrained and unconstrained patterns of interaction. That is, people who have highly formalized job duties tend to have more restricted patterns of interaction and vice versa.

Liaison devices pertain to means of horizontal interaction (e.g., between functions) and can include approaches limited to the strategic apex, informal exchanges, task teams and matrix organizations. Organizations with liaison devices limited to the strategic apex exhibit behaviors that correspond with constrained patterns of interaction. That is, people who work in organizations with no or very limited liaison devices tend to interact with a more limited set of individuals and organizations than those who have richer opportunities to interact, provided the ADR does not interfere with these opportunities. Alternatively, organizations with liaison devices extending through task teams and matrix organizations correspond to less constrained patterns of interaction.

Planning and control systems characterize how outputs can be managed through employing performance control, by action planning, or both. The more that organizations manage outputs through action planning (e.g., specific and detailed plans), the more their patterns of interaction tend to be constrained (e.g., prescribing exactly which interactions will take place). The more that such outputs are managed via control of performance (e.g., outlining high-level

results to be achieved), the less their patterns of interaction tend to be constrained (e.g., allowing for spontaneous and unanticipated interactions in addition to those that are ordinary and expected).

The Machine Bureaucracy archetype is an embodiment of high formalization, liaison devices are informal and limited to the apex. Planning and control systems are centered on action planning. Alternatively, the Edge archetype exhibits low formalization, liaison devices extending to teams and matrix organizations, and planning and control systems centered on performance control.

Distribution of Information (DoI)

One of the most significant consequences of ADR and PoI is the extent to which information is distributed. DoI can range from none to broad. The OMT variables most closely associated with distribution of information are *liaison devices* and *planning and control systems*. Organizations with few or relatively ineffective liaison mechanisms and output-managing control systems tend to maintain tight control over distribution of information and result in limited information being disseminated to limited audiences and vice versa. As noted above, the Machine Bureaucracy archetype, because it employs liaison devices limited to the apex and informal, and planning and control systems that center on action planning, can be expected to result in information that is narrowly disseminated. Alternatively, the Edge archetype, employing liaison devices extending to teams and matrix organizations, and utilizing planning and control systems that center on performance control, can be expected to disseminate information more widely.

Additional Variables

There are myriad additional variables from the C2 and OMT domains identified in the literatures of these domains, but their mapping for our present purposes is more difficult or less informative. For instance, Table 4 lists a sample of other significant variables from the C2 domain along with their meanings (SAS-050 2006; SAS-065 2008). The OMT variables outlined by Mintzberg do not correspond well with the C2 counterparts in this set.

Table 4. Sample of Additional C2 Variables

Variable	Meaning
C2 system performance	How well computer, network, and other information systems perform in support of commanders' needs
Information quality	The accuracy, completeness, consistency, correctness, currency, precision, relevance, timeliness, uncertainty, service characteristics, sharability, and source characteristics of information
Decision quality	How well commanders and others make decisions, given the quality of information
Shared awareness	The accuracy, completeness, consistency, correctness, currency, precision, relevance, timeliness, and uncertainty of shared awareness
Self-synchronization	The capability of operating-level forces to organization themselves and coordinate their time-dependent activities without hierarchical input
Agility	The ability to successfully cope with a variety of circumstances and stresses agile organizations are robust, flexible, responsive, innovative, resilient, and adaptive
Maturity	The capability of organizations to enable each of five NNEC operational capability levels: 1) Conflicted C2 enables standalone (disjoint) operations; 2) De-Conflicted enables De-Conflicted operations; 3) Coordinated C2 enables coordinated operations; 4) Collaborative C2 enables integrated operations; and 5) Edge C2 enables transformed (coherent) operations

Rosetta Stone

The relationships between the C2 and OMT variables discussed above provide a reasonable basis to outline a preliminary, metaphorical Rosetta Stone. This Rosetta Stone will facilitate efforts to relate some of the key variables from the C2 and OMT literatures to each other and both of these sets to a common approach space. The first step in the development of the Rosetta Stone is to map the OMT archetypes as shown along the top of the chart into the three sets of OMT variables that correspond to each of the C2 Approach dimension variables.

In Table 5, the OMT variables are mapped simply to the C2 Approach variables according to the scheme presented in Table 3. Looking at the Machine Bureaucracy archetype, for instance, we have high centralization, vertical specialization, and horizontal specialization. Together, these three high levels suggest unitary decision rights allocation. Likewise for patterns of interaction: high formalization, few liaison devices, and focus on action planning suggest constrained patterns of interaction. Similarly for distribution of information: few liaison devices and focus on action planning suggest tightly controlled distribution of information. The same kind of reasoning applies to the scaling of the other four archetypes. Notice the contrast between Machine Bureaucracy and Edge. This is consistent with prior research in both C2 (Alberts and Hayes 2006) and OMT (Nissen 2005).

Table 5. C2-OMT Archetype: Detail Specification

C2 Variable	OMT Variable	Machine Bureaucracy	Simple Structure	Prof. Bureaucracy	Adhocracy	Edge
Allocation of Decision Rights	Centralization	High	High	Low	Low	Low
	Vertical Specialization	High	High	Low	Low	Low
	Horizontal Specialization	High	Low	High	High	Low
Patterns of Interaction	Formalization	High	Low	Low	Low	Low
	Liaison Devices	Few	Few	Some	Many	Many
	Planning & Control Systems	Action Planning	Little	Little	Some Action	Performance Control
Distribution of Information	Liaison Devices	Few	Few	Some	Many	Many
	Planning & Control Systems	Action Planning	Little	Little	Some Action	Performance Control

Table 6 depicts the direct mapping of OMT archetypes to C2 Approach variables. We include several intermediate values for each dimension to reflect the multiple OMT variables by each C2 Approach dimension. Examining the Simple Structure for instance, like the Machine Bureaucracy, we have high centralization and high vertical specialization associated with the C2 Approach dimension *allocation of decision rights*, but unlike the Machine Bureaucracy, the Simple Structure has *low* horizontal specialization. This suggests that the allocation of decision rights is mostly unitary but not as much so as with the Machine Bureaucracy. Hence we include the label "mostly unitary" in Table 6. The same reasoning applies to the "mostly constrained" label for patterns of interaction, the "mostly controlled" label for distribution of information for the Simple

Structure, and the other intermediate labels associated with the Professional Bureaucracy and Adhocracy. Notice, alternatively, how the Edge archetype does not necessitate such intermediate labels; that is, it reflects peer-to-peer (P2P) allocation of decision rights, unconstrained patterns of interaction, and broad dissemination of information.

Table 6. C2-OMT Archetype: Summary Specification

C2 Variable	Machine Bureaucracy	Simple Structure	Prof. Bureaucracy	Adhocracy	Edge
Allocation of Decision Rights	Unitary	Mostly Unitary	Mostly P2P	Mostly P2P	P2P
Patterns of Interaction	Constrained	Mostly Constrained	Balanced	Mostly Unconstrained	Unconstrained
Distribution of Information	Controlled	Mostly Controlled	Balanced	Mostly Broad	Broad

Figure 8 shows each of the five archetypes anchored with "no organization" positioned within the C2 Approach Space. As a point of reference, "no organization" is plotted at Point A (values none, none, none). Machine Bureaucracy is placed not far away in the lower left frontal area of the diagram, reflecting unitary allocation of decision rights, constrained patterns of interaction, and controlled distribution of information. In contrast, the Edge is plotted in the upper right rear corner of the diagram (Point H), reflecting P2P allocation of decision rights, unconstrained patterns of interaction, and broad distribution of information. The Simple Structure, Professional Bureaucracy, and Adhocracy are plotted in the same manner.

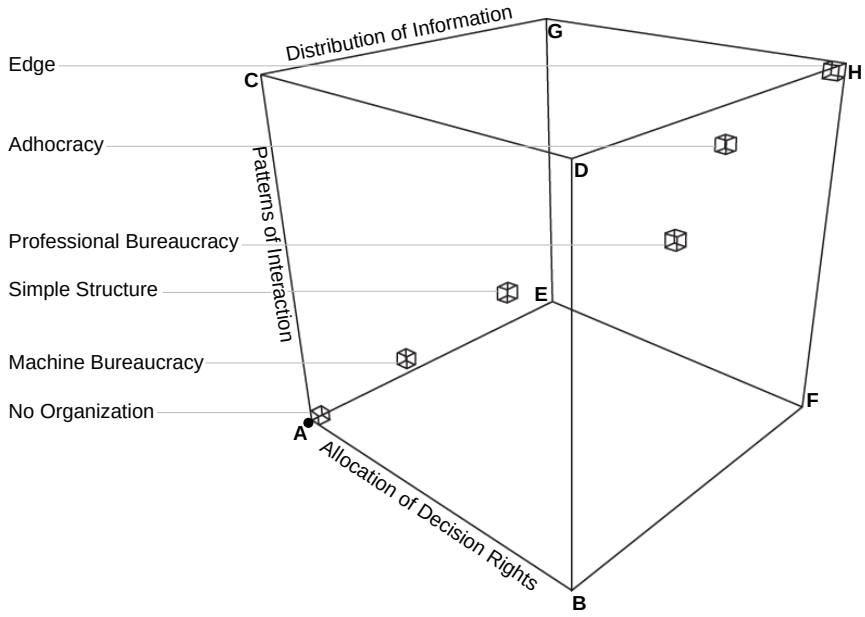

Figure 8. OMT Archetypes in the C2 Approach Space

Notice how these latter three archetypes reflect something of intermediate positions within the C2 Approach Space with plot points that are not as extreme as those positioning the Machine Bureaucracy and Edge. More precisely, whereas the Machine Bureaucracy and Edge plot at opposite corners of the space, the other archetypes plot at different points within the space. The Simple Structure plots relatively close to the Machine Bureaucracy and the Professional Bureaucracy and Adhocracy plot relatively closer to the Edge. This provides us with visual representation of alternate organizational forms and how they relate to different C2 Approaches.

Notice further how most of the corners depicted in the C2 Approach Space do not have archetypes plotted at them. Indeed, aside from the corners corresponding to the Machine Bureaucracy (Point A) and Edge (Point H), all other vertices are empty and labeled simply with a capital letter to identify them. For instance, in contrast with

the Machine Bureaucracy, Corner B reflects P2P decision rights allocation, but is consistent in terms of constrained patterns of interaction and controlled distribution of information. It is unclear how a corresponding organizational form would reflect this C2 Approach, but the figure suggests that such form and approach are possible in theory. In this sense, the diagram represents something of a C2 Approach *generator*: the various vertices, edges, planes, and points within the space all represent theoretically possible C2 Approaches with corresponding organizational forms. Identifying, understanding, and comparing such forms represents a fascinating topic for future research, as does empirical comparison and contrast with operational C2 organizations in the field.

OMT and C2 Archetypes within a Common Approach Space

The ability to map both the OMT and C2 Approach archetypes onto the same approach space enables comparisons in a way that was not previously possible. This will also facilitate parallel exploration of the Approach Space and the implications of different regions within this space by researchers from both communities. Figure 9 depicts a correspondence between the scales developed for the C2 Approaches and the OMT archetypes. This is essentially a reproduction of the scale depicted above with an overlay of the OMT archetypes as summarized in Table 6.

For instance, "Conflicted C2" is plotted on the left of the top scale (i.e., with no allocation of decision rights) and corresponds with the "No Organization" OMT archetype plotted at the same point on the scale. Similarly, The De-Conflicted C2 Approach plots as a range toward the left end of this same scale, and the OMT Machine Bureaucracy archetype plots within this range (i.e., unitary allocation of decision rights). The same applies to the other C2 Approaches

and OMT archetypes across the three scales. This overlay enables us to depict C2 Approaches and OMT archetypes in the same C2 Approach Space.

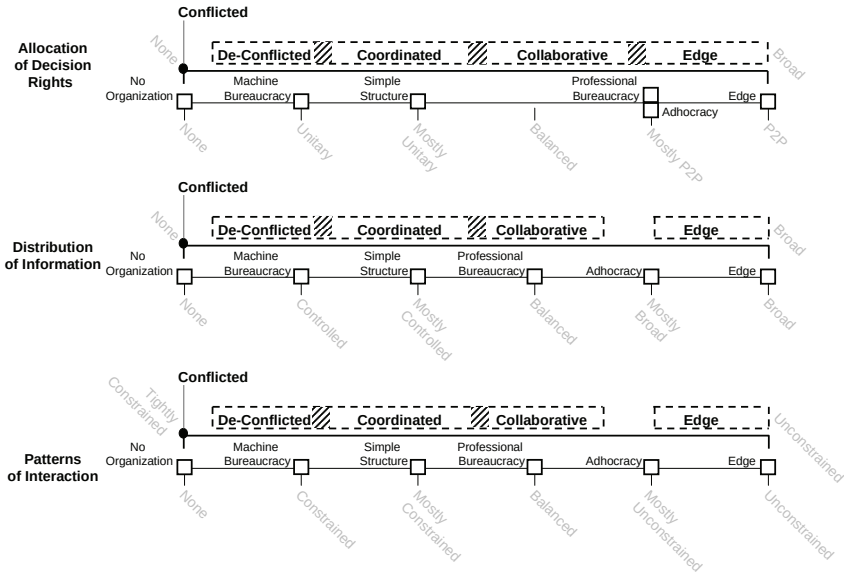

Figure 9. Combined C2 and OMT Approach Scales

Such depiction in a common approach space is presented in Figure 10. Immediately one can see that the OMT archetypes map to areas that are adjacent to or, in part, overlap C2 archetypes. As above, Conflicted C2 corresponds to No Organization. The mapping is precise and the concepts synonymous. Machine Bureaucracy abuts both De-Conflicted C2 and Coordinated C2. The Machine Bureaucracy appears to bridge the two C2 Approaches. Simple Structure falls within Coordinated C2. The archetypes reflect considerable balance across all three dimensions. Adhocracy abuts Edge C2, and Edge sits at the opposite corner of the Edge C2 Approach. Adhocracy and Edge define two extremes of the Edge approach.

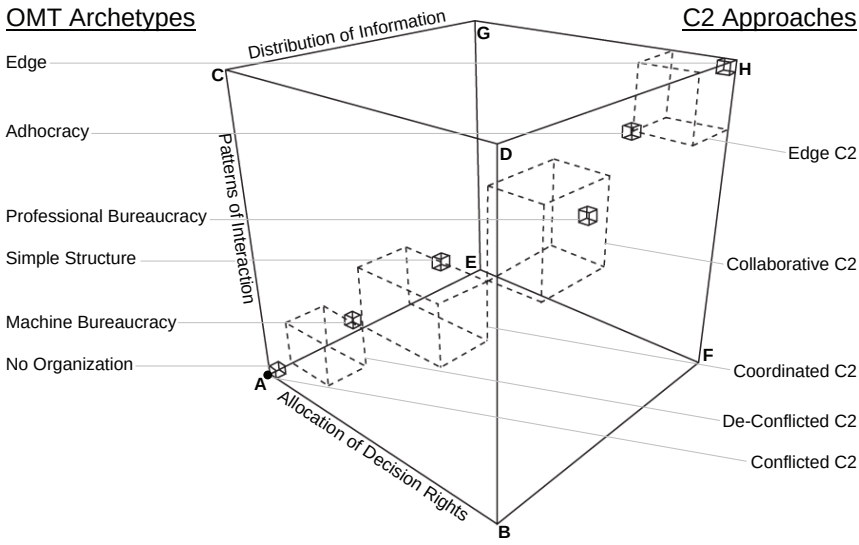

Figure 10. OMT and C2 Archetypes in a Common Approach Space

The theories that underpin the C2 Approaches and the OMT archetypes are totally independent and come from observing different types of organizations engaged in very different endeavors. Nonetheless, through this Rosetta Stone we are able to interrelate them clearly and directly through a common set of dimensions and scales. Furthermore the two perspectives are different. The C2 Approaches were developed for both standing military organizations and collectives involving both militaries and civilian organizations with no a priori structure. The OMT archetypes were idealized from observed civil organizations. This represents a substantial theoretic contribution to both the C2 and OMT literatures. Future research in this area will undoubtedly involve attempts to develop quantitative measures of these three dimensions of the approach space, obtain data empirically. As a result, the regions of this approach space will be refined.

Practical Illustration

As part of its efforts to validate the conceptual model of C2 Maturity, the SAS-065 Research Task Group undertook a number of case studies, simulations, and analyses of available experimental data. They wanted to determine if this model could be usefully applied to structure C2-related problems, develop lessons learned from operations, design experiments, and the like. We build upon this work to illustrate how our conceptual integration applies to organizations and C2 Approaches in practice as well as to theory.

For instance, using data collected and analyzed in the case (SAS-065 2008), we interpret one case pertaining to air operations in the Kosovo Force (KFOR). Based upon the case as secondary data, the C2 Approach to this operation plots roughly as depicted in Figure 11. Notice that it does not fall neatly within any of the C2 archetypes depicted in the figure or described above. Two of the three dimensions correspond to Coordinated C2, while the third dimension corresponds to De-Conflicted C2. Hence the KFOR C2 Approach represents something of a hybrid between Coordinated and De-Conflicted C2. This illustrates how our theoretical C2 archetypes can be used to depict and classify operational C2 Approaches in the field, but such operational approaches need not correspond to only a single archetype. This result mirrors the long-standing understanding in the OMT literature that operational organizations in practice can represent hybrids of any two or more OMT archetypes.

Interestingly, the OMT archetype Machine Bureaucracy maps more closely to the KFOR Air Case in the C2 Approach Space than any of the archetypical C2 Approaches. Given that the Machine Bureaucracy is noted to correspond well to most contemporary military organizations (Gateau, Leweling, Looney, and Nissen 2007; Looney and Nissen 2006; Nissen 2005), this result is easy to interpret, namely that KFOR Air has the characteristics of a typical Industrial Age military organization.

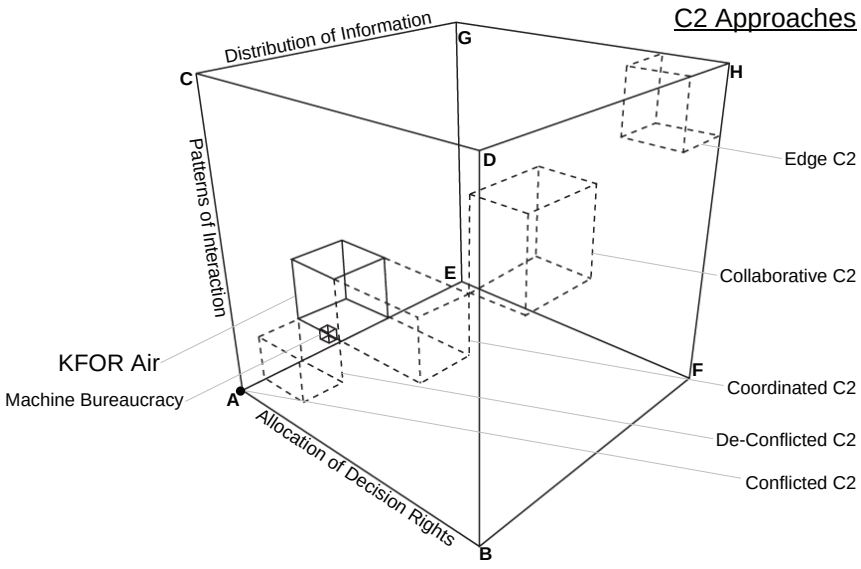

Figure 11. Case Study Results

The ability of our Rosetta Stone to combine theory from both the C2 and OMT fields demonstrates a strong theoretical contribution. Its ability to depict operational C2 Approaches and military organizations in the field provides a measure of external validity and practical applicability of the approach. Of course, this represents only the first step. Many other C2 Approaches, military, and other organizations need to be analyzed in similar fashion, but now both the C2 and OMT communities have an approach to doing so and to sharing their results with one another.

Conclusion

A variety of academic disciplines and professional organizations address how collections of individuals and organizations combine their individual resources and efforts to accomplish collective objectives. However, these largely disjointed communities of researchers

and practitioners have developed their own concepts, models, and languages. They focus on different yet complementary issues, levels of analysis, sets of variables, and like aspects of research. Addressing recent calls in the literature for increased semantic interoperability and interaction across these communities, we build upon current work focused on bridging communities through concepts from the fields of command and control and contingency theory. We develop multidisciplinary formulations of the C2 Approach Space and the concept *C2 Maturity*.

In particular, we summarize the key concepts and variables in both the C2 and organization and management literatures and use the increasingly well-understood contrast between hierarchical and edge approaches to C2, and the corresponding organization and management structures, to give such concepts and variables concrete application. We then develop a metaphorical Rosetta Stone, in the form of a common approach space and use the concept of C2 Maturity to interrelate such concepts and variables across domains.

Results of mapping such concepts and variables across the two fields of study reveals considerable correspondence. We show how a variety of C2 Approach archetypes and organizational archetypes can be examined together within a concise set of three dimensions. Moreover, we illustrate how such diverse archetypes can be visualized together in terms of this same, three-dimensional model. This represents a substantial theoretic contribution to both the C2 and OMT domains. Further, we demonstrate how this theoretical model, our metaphorical Rosetta Stone, has practical application by examining how an operational C2 Approach observed in the field can be mapped to the model and compared to archetypes from both domains. This illustrates how our conceptual integration applies to organizations and C2 Approaches in practice as well as to theory.

We also document the fact that there are a number of variables considered important by the C2 community that do not seem to have a corresponding OMT variable. This conclusion argues for a

set of cross-domain research initiatives that are focused on a better understanding of these variables in the context of a variety of organizations and collectives.

Thus, with such development of a common approach space, one that can be used to describe both a variety of C2 Approaches (e.g., including C2 Approach archetypes, approaches observed in actual operations, and experimental approaches) and a variety of approaches to OMT (e.g., including OMT archetypes, observed organizational behaviors, and organizational treatments), we have taken the first step toward building a conceptual bridge between these two communities.

Indeed, apparently for the first time, C2 researchers can describe various C2 Approaches to OMT researchers and relate such approaches to organizational archetypes. Likewise, and again, apparently for the first time, OMT researchers can describe various organizational archetypes to C2 researchers and relate such archetypes to C2 Approaches. With this, we facilitate richer and broader interaction between these traditionally disconnected research disciplines. We also move the state of C2 research out of its stereotypical, conflicted behavior.

Table 7. Key Challenges

Challenges
Developing Improved Scales for the Dimensions of the Approach Space
Operationalizing Agility
Exploring Edge Approaches and Other Relatively Unexplored Regions of the Approach Space
Exploring the Relationships Between the Collective C2 Maturity and Entity C2-OMT Approach Maturity
Understanding Requite Maturity and Agility

However, much work remains to be done to enable potential synergies between these two and related disciplines. To conclude this section, we identify the five interrelated research challenges (summarized in Table 7) that we believe deserve priority attention. The first two address fundamental issues of definition and measurement. Development of the scales for the OMT archetypes results in an ordinal arrangement that mirrors theory but leaves many important aspects underspecified. Moreover, those developed for the C2 archetypes—although reflecting interval scales developed through expert judgment—leave a great deal of room for elaboration and precision. Likewise, the concept of agility is both intuitively and theoretically appealing, but it remains difficult to operationalize. Indeed, this compound concept is comprised of six underlying concepts (e.g., robustness, resilience, flexibility), which themselves remain difficult to operationalize. Improvements in these areas are needed to enhance rigor and to explore new ways more systematically for accomplishing the processes that we associate with C2, organization, management, and governance.

The other three challenges involve fleshing out our understanding of the various regions in the combined approach space, their contingent appropriateness as a function of circumstances, and the costs and benefits of more mature approaches such as edge or edge-like organization/C2. Theoretical work is needed to understand the implications of the myriad corners, edges, planes, and points in the approach space that do not have archetypes mapped to them. Some of these may offer promise in terms of outlining currently unknown C2 Approaches and organizations that are appropriate for certain mission-environmental contexts. In this sense, the approach space can serve as a generator of new approaches and organizations.

Likewise, the concept *Maturity* offers good potential for description, explanation, and possibly even prescription. However, we need to explore how the maturity of collectives (e.g., coalitions) interrelates with that of single entities (e.g., organizations). The related concept

requisite maturity[17] suggests that, in a contingency theoretical way, higher maturity may not be "better" in all cases. Given that higher maturity levels are likely to be more difficult and costly to attain, levels that are too high for a particular mission-environmental context may be counterproductive. We are only beginning to formulate the appropriate research questions to address these challenges. Much research remains to be conducted. However, with this conceptual integration, hopefully we can engage in such research through the combined and integrated efforts of the C2 and OMT communities.

17. *Requisite maturity* refers to the level of C2 Maturity that is required to deal with the situation at hand.

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